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ABSTRACT

A review of expert opinion and recent literature on the critical issues and open questions relating to the economics of the scientific and technical information industry shows that there is hardly an area that does not call for more and better research--yet the need is not nearly so much for quantity as for a more coherent and meaningful pattern. Development of such a pattern depends to a large extent upon a body of fundamental information about the field itself. This foundation is simply not available at present. A broad effort is needed to collect available data, together with development of standardized collection methodologies which can meet critical scrutiny as well as provide the necessary additional comparative and additive information. Increased research and policy study of the roles and processes of information diffusion into the private sector is also needed. (Author)

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A CRITICAL REVIEW OF RESEARCH RELATED TO THE ECONOMICS OF THE SCIENTIFIC AND TECHNICAL INFORMATION INDUSTRY

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ABSTRACT

Based on a review of expert opinion and recent literature, this report highlights the critical issues and open questions relating to the economics of the scientific and technical information industry. There is hardly an area that does not call for more and better research--yet the need is not nearly so much for quantity as for a more coherent and meaningful pattern. Development of such a pattern depends to a large extent upon a body of fundamental information about the field itself. This foundation is simply not available at present. The authors recommend a broad effort to collect available data, together with development of standardized collection methodologies which can meet critical scrutiny as well as provide the necessary additional comparative and additive information. The report further stresses a strong need for increased research and policy study of the roles and processes of information diffusion into the private sector.

INTRODUCTION

In the years since World War II America's level of technology and scientific activity have expanded continually. Concurrently, an elaborate array of information and communication systems has been developed to document, store, and distribute the information upon which this activity depends. Yet even simple facts regarding the size of this industry and its role and utilization by the scientific community are poorly understood. Scientific and technical information components have grown largely on an *ad hoc* basis, supported at times as a research service, at others as an archival tradition, sometimes as a government effort to shape the directions of research . . . and often as an entrepreneurial response to apparent needs.

Scientific and technical information services have grown on an ad hoc basis.

The size and intricacy of the resulting system is substantial, and its fragmented growth is reflected in innumerable questions about its goals, value, and role in the scientific process, not to mention the measures of cost and utilization. Unfortunately this confusion is not also reflected by a lack of "opinion", research, and publication.

The intricate and fragmented growth is reflected in questions of goal, value, and role.

During the course of this project we have attempted to review, assess, and synthesize both recent literature and the experience and opinion of representative participants in the field. Scientific information is neither fish nor fowl. It is sometimes a product, sometimes a service, sometimes a supporting contribution to the public good, sometimes an item or process to be traded and sold on the open market. Its value or application may be a matter of speculation undetermined for

The value and nature of information are often ambiguous.

years, only to become an invisible contribution to a seemingly unrelated concept . . . or, worse yet, reinvented because of system failure.

Economic techniques should contribute insight ...

In weighing questions of information value and resource allocation, it has become increasingly obvious that economic analysis techniques should be able to contribute insight and more rational grounds for decisions. Unfortunately what is not perhaps as obvious are the limitations of such techniques and the formidable gap between theoretical models and their application to practical problems, especially where little or no data exists. In our review we have seen repeated attempts to develop models of information use and value based upon such inappropriate or severely limiting assumptions that the results are at best an academic exercise. Again and again we have seen elaborate circular arguments, often embellished with mathematics and jargon, yet basically designed not to model a real world process but to prove an unreal assumption.

but are often severely limited by restrictive assumptions and circular reasoning.

Time after time we have noted attempts to draw conclusions from unacceptable data or based upon inadequate or inexperienced methodology. Desirable as it may be to do otherwise, data cannot be added or compared or considered scientific unless its collection methodology can be duplicated. The percentage of activities which cannot meet this simple test is disconcerting.

Data is difficult to collect and often not valid.

Perhaps most impressive in this melange has been the substantial difference in orientation, methodology, and language of the economics and information communities. In the following discussion we have tried to bridge this chasm, adopting the role of interpreters and attempting to reflect the essential issues in terms of English instead of jargon. If the result seems

This study attempts to interpret the orientation, methodology, and language of this very amorphous research area.

consequently less impressive, perhaps it is justified by the potential for mutual understanding of the problems.

In the course of this project we have reviewed salient material from several hundred articles from the U.S. and Great Britain. While many of our conclusions and recommendations are based on examination of the literature, we also talked with representatives of large government information services for the scientific and technical information community; of nongovernment, non-profit services; of nongovernment, for-profit services; and of professional and trade associations in the information field; as well as a variety of professional information scientists, librarians, and economists.

The project surveyed both literature and expert opinion.

In November, 1974, we cosponsored with the American Society for Information Science (ASIS) a Panel on Policies and Directions in the Research on Scientific and Technical Information Marketing Economics, with the following participants:

It convened a special panel to debate the policy issues of marketing economics.

Harry M. Allcock, IFI/Plenum Data Company
Curtis Benjamin, McGraw-Hill, Inc.
Sanford Berg, University of Florida
Patricia Brown, Battelle
Helene Ebenfield, NSF, Office of Science Information Service
Conyers Herring, Bell Laboratories
Edwin Parker, Stanford University
Hubert Sauter, Defense Documentation Center
Josh Smith, American Society for Information Science
George Tressel, Battelle.

The discussion was lively, reflecting the same problems we noted in the literature: confusion of meaning, detachment from ultimate users, and conflict of experience. The complete conference was televised and the tape gross edited to select the highlights and reduce the viewing time. The original meeting lasted six hours; the rough cut edited version is two and a half hours.*

Confrontation helped focus on commonalities and differences--of perspective as well as language.

Key points emerging from the session were summarized as

- We need to better understand the overall flow and use of scientific and technical information
- There must be greater study of the information marketplace and the government role
- The characteristics of information are unique: neither a conventional product nor a public good
- Economic studies might address market elasticity, copyright effects, and economies of scale
- We need to study the effectiveness of information transfer and alternatives to publication
- We need to question the assumptions of past economic studies and apply such research to practical problems
- The ultimate use and justification of the system lies outside the R & D community

* Requests to view the tapes, which are available in 3/4 inch or 1/2 inch cassette should be directed to Josh Smith, ASIS.

- We need to adapt information technology to information use, rather than vice versa
- We need products that bridge the research and development, application and utilization gap.

We have attempted in the following discussion not to detail the research in this field but rather to provide an overview of the issues and an indication of vacancies, deficiencies, and outstanding questions which we feel should be addressed. It is not our intent to describe "Everything You Always Wanted to Know About Information Economics" but instead to point out the many provocative questions which remain.

This report attempts to survey the salient issues, deficiencies, and outstanding questions.

Throughout our project we have been encouraged by the patience and assistance of Joel Goldhar and Helene Ebenfield, not to mention their invaluable sense of humor. We commend possession of this quality to any one contemplating the sound and fury of information economics.

THE TRANSFER OF KNOWLEDGE

It is the goal and thrust of economics to develop models which can be used to describe activity and predict its equilibrium under differing conditions. The attempts to apply such techniques to technical information have been preliminary, poorly understood by the information community, and so far unable to produce substantive predictions.

Research in information economics is largely exploratory ...

To understand and appreciate the depth of the difficulty, one must first recognize the complexity and diffusion of the technical information community. Its components and participants have grown independently to serve scattered users with radically differing needs. As a result, the economist entering the field is hard pressed to describe this many-tailed elephant.

it faces an exceedingly complex community.

Knowledge is both the means and ends of science . . . a constant extrapolation of past knowledge and its application to new problems. In practice this process can be only partially systematic. Not only is it difficult to regiment synergism and insight, but also the appearance or recognition of an important new problem can significantly shift the focus of major activities. Consequently, the value of information remains ambiguous, and even the field of its use may change over a period of time.

Knowledge is both a means and an end ...

characterized by ambiguity and change.

In response to this process an elaborate web of information activities has developed, providing the documentation, storage, searching, and communication services inherent in the development and application of new knowledge. Thus, when considering an economic model it is necessary to recognize that its definition of

Information services attempt to support the collection and use of this ambiguous commodity.

information activities must inevitably impose an artificial boundary, arbitrarily lifting certain formal services from the milieu of research, development, and application. The model designer must further recognize the complex character of this milieu and the radical differences of goals, methodology, and needs which are encompassed.

Models and descriptions cannot match the complexities of this milieu.

The accretion and extension of knowledge in basic research (Fig. 1), and its comparatively open *exchange* of new information is inherently unlike the tortured and competitive *diffusion process* by which information is combined, modified and converted to technology in the private sector (Fig. 2). To this picture must be added the constant trading and reinterpretation of information as it is passed between fields as well as the volumes of unpublished art and data held by the private sector. The process is so elaborate that any discussion must necessarily be overly simplistic and every model be limited to a small portion of the overall activity.

Two basic roles: exchange in the R & D community, diffusion to the private sector.

Nonetheless, attempts to develop such models reflect real issues, and the effort promises some additional insight. We dwell upon the complexity involved only because it tends to produce a substantial communication and credibility gap between the fields of information and economics. There appears to be a frequent misunderstanding of the probable role and value of economic models, sometimes accompanied by a lack of respect for the limitations which their assumptions impose.

Models face inevitable problems of over simplification.

* * *

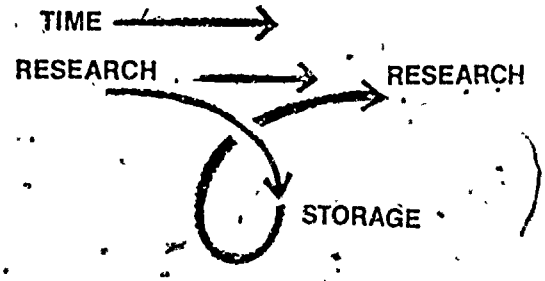

Figure 1. The Basic Flow of Research Information in a Single Field

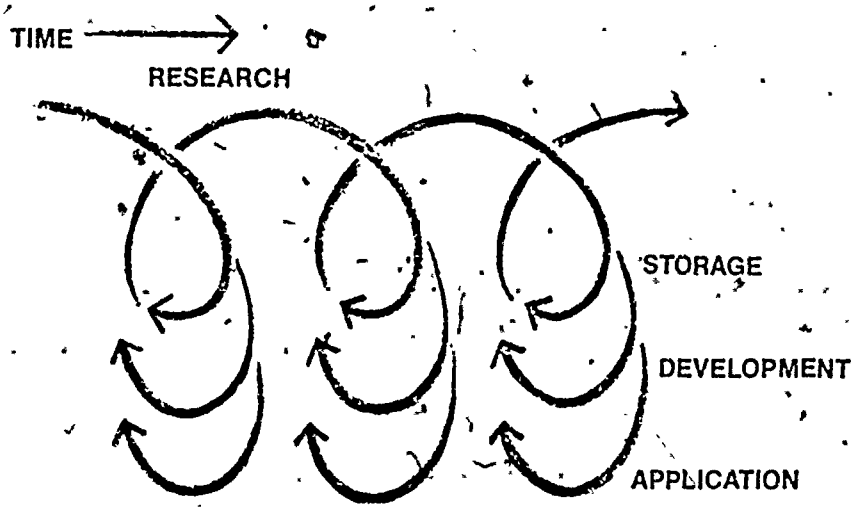

Figure 2. The Diffusion of Research Information Into the Realm of Technology

Ultimately, technical information services can only be viewed as a segment of the total research, development, and technology framework of which they are a part. Thus, in the end, the *value* of such information services must be weighed against the goals of this sprawling system of exploration. Information systems are not an end unto themselves. And while considering their value we must examine these systems independently of a much larger array of communication activity to which they are related.

The value of information services can only be weighed in the light of the research which they support.

The demarcation is sometimes difficult to establish. The science and technology community is far from monolithic. Its activities are scattered among public and private, governmental and academic, philanthropic and entrepreneurial organizations, funded and directed partially in the direct public interest, partially in the interest of increased productivity, private gain, and entrepreneurial venture. And in the same vein, technical information services embrace a wide range of public and private goals, tied together by innumerable political, professional, and financial feedback loops. To complicate this picture still further, there is an almost abysmal lack of data regarding the overall quantity, costs, and use of scientific and technical information. In the absence of such fundamental data it is difficult to make any broad generalizations about the activity, much less test the validity and value of economic models.

There is little data to support generalizations or models.

Nonetheless, information activities represent substantial investments by both the public and private sectors, and both the level and manner of subsidy by the federal government must be subject to serious question. One cannot avoid the need to weigh cost and value. It may well be impossible to do this as an economist might

wish . . . by intellectually converting the products, processes, and benefits of science and technology into "equivalent dollars". But by developing valid and comparable data in limited areas of activity, and by developing models whose assumptions and applications are sharply defined . . . by combining the operational experience of information scientists with the theoretical perspective of economists, it should be possible to greatly improve our insight and separate fact from judgment.

Yet, by combining experience and theory we can develop insight.

THE VALUE OF INFORMATION

Substantial effort has been devoted to directly confronting the central issue of information *value* (and hence the value of the services which process and distribute information). While some of this has been directed toward the adaptation of economic concepts and models, the great majority of this publication consists of reflection, experience, and opinion--largely intuitive and often repetitious. A number of themes and weaknesses appear regularly.

Most discussion of value is simply opinion.

It is often assumed that information may be assigned a nominal value, however crude, based upon its use, its market value in some cost-recovery or market-choice system, or through some *ad hoc* agreement by users. Yet the value of individual items remains a mystery. In a "market-choice" situation the information customer rarely, if ever, is confronted with a truly rational choice, or has assurance that the service will provide the information desired or indeed anything useful. Rather he invests in a quest for information based upon past experience, prejudice, and lord-knows-how-many other intangibles. Attempts to model the process tend to confront this ambiguity and the model cannot be generalized without innumerable qualifications.

"Market choice" is rarely appropriate ...

Even if value discussions did embrace the full range of the research cycle to include the cost of research and the ultimate application, no model or formula can replace the user's judgment regarding priorities and values, though it may provide insight into his rationale. Instead we can only look for definitions and measures which have been legitimized by consensus. Yet *ad hoc*

And "value" must ultimately reflect judgment and consensus.

models and consensus are always subject to examination of their conclusions, and those who disagree with the conclusions will retract their consensus. Thus, the credibility of conclusions is often a test of the model rather than a benefit of its insight.

Since the value of information is an intangible which may not be apparent for many years, most services must face a dual role, the *archival* storage of information for future use and its *dissemination* for short-term application. Most research and hence most scientific and technical information is justified as either of immediate or long-term social benefit, though this benefit may be so dispersed as to make detailed identification and measurement difficult. Such "externality" is traditionally called upon to justify government subsidy of products and services which we would like but can't pay for. The topic is also enjoying a current popularity among economists, and there is some store of available theory. Unfortunately, when applied to practical information issues, the results are not always convincing.

Information services are concerned with archival storage and dissemination.

Both provide social benefit ...

> *Maxim: for optimum social benefit a public good should be priced below the marginal cost of production.*

Even the authors are not sure about this one. In the case of many information products, the marginal cost may be extremely low and the resulting subsidy beyond reasonable expectations.

If the logic and results seem less than convincing, we suggest that some of the assumptions may be in error . . . information cannot always be considered a simple "public good", a product in which we have

But information is not a simple "public good".

invested with a specific intent of broad utilization and benefit. As the terminal stage of research (which is also usually a public good) archival storage may often be the only alternative to loss of a public investment. To the extent that short-term usage is directed toward general benefit, as in basic research, or applied to increased general productivity, as in broad new technologies, this too, can be considered a public good.

Information is also a basis of technology, a marketable commodity.

But some research, more development, and a great deal of application technology are a stock in trade of private enterprise, subject to routine market activities of barter, sale, and theft. The same knowledge may play both roles. It may slip inconspicuously from one role to the other. And its value may appreciate or depreciate sharply in the process. Thus, information has been rightfully referred to as a *semipublic good*, though the distinction is often ignored in building models.

Thus information must be considered a semipublic good.

There are two key roles in the information community: first, a short-term or long-term support of the basic cycle of research and knowledge generation, and second, a support of the diffusion process through which this knowledge is converted to technology and productivity. In the light of this perspective one may well be tempted to measure (or recover the value of) the impacts of information flow on the engineering community through some technique such as efficiency or productivity measurement. In similar fashion, one may also examine the value of a service to the research worker in terms of his time or willingness to trade for some other service to which a value can be imputed. In both cases one is faced again with an inability to measure value directly and hence a need to measure some *related* quantity which will hopefully provide an indirect *indication* of value.

Value must usually be imputed from some related quantity.

If such techniques were better developed, more precisely defined, more reproducible, and their limitations more fully recognized, they could provide a useful though restricted reflection of value, but they are not. In only a few cases are the definitions tightly drawn and the methodology sufficiently rigorous that the experience might be compared or replicated. These cases tend to be limited in scope and we see a clear need to develop well-defined techniques for "inferred" value measures.

Well defined, reproducible methodology is needed.

* * *

There appears to be a striking trade-off of scope versus credibility in information value studies, a kind of uncertainty principle resulting from the overall system complexity. One can easily find examples of valid system studies whose area was limited to a specialized service or product, and where the methodology was defensible, reproducible, and useful for that particular system. Conversely there are numerous examples of global models which attempt to contain and define the ultimate value of information as a whole. On close examination, however, one is impressed by the need for severely limiting assumptions and a total inability to define measurement techniques . . . much less undertake any practical application. Such efforts are often embellished with an awesome array of mathematical terminology and when at the end they reach our favorite conclusions, one can easily believe that economic science is coming to the rescue of intuition. Yet attractive conclusions based on untenable assumptions are less than convincing regardless of one's manipulative skill. It seems more likely that sound studies of restricted areas

There is a trade-off of scope vs credibility in value studies.

Global models may be of less use than documented anecdotes.

could result in an "anecdotal" pattern that would be far more convincing, and such "storytelling" would also be a better research method than crude modeling.

It is a general weakness of information science that its practitioners have little familiarity with either the tools of micro-economics or the techniques of operations analysis needed to observe and measure their own activities. At the same time it is an unusual economist who graduates with more than the most superficial acquaintance with the problems of data definition, measurement, and replicability necessary to support his models. Thus, economists not only often face an inadequate insight into information activities but also are poorly trained to cope with the data and measurement problems that information services present.

Few economists have the necessary expertise to deal with the formidable data gathering problems of the information community.

There appears to be a clear need for a third skill or thrust to establish a body of data against which economic concepts can be tested. An increased emphasis on the development of standard measurement procedures could provide both a basis for overall data collection and a body of anecdotal studies. To achieve this will require interdisciplinary efforts combining information specialists, operations analysts, and economists. Too many past efforts have involved ineffectual attempts by well-meaning "amateurs" whose learning curve exceeded the project life: innocents often rush in where professionals fear to tread. Meanwhile, it is our opinion that thus far, global models are more awe-inspiring than convincing, and a body of less ambitious micro-economic studies would be more useful.

Both the strategy and the techniques of experienced operations analysts are needed.

THE USE OF INFORMATION

In assessing the effectiveness of information systems, the value of their services and their role in the flow of science and technology, the ultimate use of information remains elusive and difficult to document. It has been possible, in some specialized instances, to indicate the economic value of a patent or technique in terms of the cost of alternative technology, but such measures are difficult to identify or quantify . . . and still more difficult to generalize. At the same time, the impact in a specific case may depend greatly upon the vicissitudes of a particular business environment, the current market pressures, the presence of a champion, the competitive technology, the age of the industry, capital requirements, and engineering sophistication, to mention only a few. So an attractive anecdote may, on close examination, lack general credibility, or the role of information may be masked by other factors.

It is difficult to document the use of an idea.

In a more general manner, studies have shown repeatedly the cascading impact of truly critical discoveries, such as in solid state physics and plant genetics. While such reports have an impressive qualitative credibility, it is difficult to assign economic value in more than relative terms. It is also tempting to continually expand the definitions of information and impact, until information use extends far beyond the realm of scientific and technical information, to include almost every type of communication and reporting transaction. From this perspective one may be led to believe that the value of information is only slightly less than the gross national product.

In almost every case, however, the observation and documentation of information patterns remains frustratingly removed from the actual information use, and it is difficult, if not impossible, to follow an item to its ultimate end. Synergism is the essence of science and technology, and the importance of a particular item may be insignificant in isolation though critical to the process. In some applications a specific item of information is essential, while in others *some* information is necessary, but no specific item is critical.

Use of information may be casual and indirect.

We know too little about the flow of information at the user's level. We know that there is no single pattern, and that a truly efficient system, able to retrieve specific items with dispatch, may actually be disliked by the class of user who prefers to browse and is not perfectly clear about his own needs. The information "customer" may serve himself or send an intermediary. Alternatively, he may be or use a "gatekeeper", one of the two-legged switching centers who compulsively exploit information resources to become walking encyclopedias. Without better understanding of these patterns it is difficult to assess even the relative performance of systems and services.

The "customer" may not appear directly.

Perhaps most disturbing from the perspective of the economist or market analyst is the series of seemingly endless studies (usually through a simplistic questionnaire) of the information *user*. Meanwhile, both studies and intuition indicate a substantially larger population of apparent *nonusers* . . . persons who rarely if ever call upon the services of our costly archival and distribution systems. This does not mean that these people are ineffective users or that they are without information resources, nor even that they lack

We need to study the activity of the non-user.

information filtering in some way from the formal system. We simply do not know.

If we knew more about these real patterns of information use, rather than just those related to a specific service, we might better assess the performance of our institutions and our allocation of resources. Perhaps more important, we suspect that such understanding would point the way to a variety of new services which could more effectively serve our real needs.

Better understanding of information use patterns is also basic to new services.

THE COST OF INFORMATION

In a substantially more pragmatic and less exotic manner than attempts to assess value and use, one may simply examine the detailed costs of information processing . . . weighing these against the products and services provided. Here again, however, one must define the boundaries of information service and recognize that they can only artifically be separated from the research and development process. Is the cost of research not part of the cost of its final report? Should the cost of writing and editing be included? Is the cost of journal publication a terminal cost of the original research or the initial cost of storage and distribution?

What is included in the cost of information?

The accounting practices and definitions in government, industry, and academia are often so different as to preclude integration or comparison. At the expense of redundancy one can only repeat that some development of standardized definitions and methodology would prove extremely useful, even if applicable to only portions of the industry.

Accounting practices vary.

Likewise it would be highly desirable that such reporting practices be defined in ways that would allow their use in testing economic models or at least a speculative assignment of costs to different roles of the information community. One may consider, for example, that information activities comprise three basic roles--archival, dissemination within the scientific community, and diffusion into the private sector--so it would be useful to identify and isolate the associated costs. These questions become especially relevant when one addresses the costs that are inherent in the research process itself, as opposed to the cost of effective

Three types of activity:
archival
dissemination
diffusion

utilization and technology transfer, as well as questions regarding the cost and value of new services to "marketing" of information to the private sector.

Archival material is the direct output of research.

Archival activities of reporting, publication, indexing, and storage are the terminal activity of research. They are in fact the packaging and storage of its output. As such they are clearly directed toward long-term social benefit, and subsidy of the associated cost seems implied in the original research. One might similarly infer that long-term public interest depends upon the ability to store and retrieve the salient *information* rather than simple location of documents. A variety of indexing, synthesizing, and analysis activities would thus be included.

Dissemination is the direct input to research.

In a similar manner one might consider that dissemination, retrieval, and review activities are direct input into the next cycle of research and the associated costs could be directly attributed to this activity.

Diffusion is the conversion to technology in the private sector.

Finally, still other information services are devoted to the process of diffusion into the private sector and their costs might well be subject to recovery or at least weighed against their benefits.

We should separate these costs.

If information activities and their associated costs could be documented and manipulated along even such broad general lines it would provide a substantially greater insight into what we pay for information service and why. It would allow us to consider and compare the costs that are inherent in the research process itself as opposed to those related to the cost of effective utilization and technology transfer. Yet any such inquiry must await the availability of appropriate definitions and methodology which can be replicated and extended consistently to different information activities. Some very

useful preliminary efforts have been undertaken in this direction, and one must hope that they will be continued. Consistency is an essential ingredient of the scientific method, and an inability to compare related studies is a frustrating theme of information economics research.

Some studies have begun to explore input vs retrieval costs and alternative methods of subvention.

In most information services which involve an archival function, it would be desirable and at least theoretically possible to separate the cost of input processing and archival storage from the user-oriented costs of searching, retrieving, and distribution. It would also be useful to examine these costs in order to explore alternative approaches to subvention. For example, a number of suggestions and some experiments (through credit accounts, voucher systems, etc.) have been directed toward subsidizing the user rather than the library or information service, and the results are somewhat encouraging--but the efforts are preliminary and a great deal remains to be learned about the effects on user patterns and the information system itself.

There is a substantial theory of cost benefit analysis.

There is a substantial theory of cost benefit analysis which can be applied to information services, providing one respects its requirements and limitations. Defensible cost benefit analysis requires identification and definition of quantifiable and replicable factors. In turn it necessitates the exclusion of factors which are value judgments or otherwise nonmeasurable. Subject to these constraints, it is possible methodically to define and isolate the costs and benefits of a system. The exclusion of nonmeasurable factors does not imply any less significance but rather an attempt to improve perspective through analysis of those factors which <u>are</u> measurable. A somewhat more restrictive variation on this theme is the study of cost effectiveness, which through systematic examination attempts to optimize the

efficiency of a system in reaching its operational goals.

A principal problem in attempting to review such studies has been the substantial difference in definitions and methodology, making it almost impossible to combine or compare experience. A key requirement in reporting any such analysis should be a detailed description of exactly why and how the study was conducted, how costs were determined, itemizing exactly which factors were included (so that other summations are possible), and explaining those excluded. Unfortunately the information community consists of such a variety of institutions and organizations with so many different accounting practices that some do not even recognize their use of unusual (to say the least) accounting definitions, much less how inappropriate they may be to economic cost considerations.

Studies are rarely additive or comparable, due to differing methodology..

THE MARKETING OF INFORMATION

Cost recovery and user charges are popular patent medicine for information services with economic ills, but the patient has not always recovered from the treatment. In theory one might assume that such charges could both distribute the cost of information and reflect its equivalent value to the individual user. However, the surprise-package nature of information makes user choice far from a rational decision, and the motivations for purchase of services may reflect affluence, status, personal style, tradition, or any number of other impulses other than direct utility.

Cost recovery is a popular topic but difficult to apply ...

In some cases a substantial portion of service costs has been recovered in this manner; yet the effect of this policy on the spectrum of information products is not clear, nor is its impact on the overall pattern of research, development, and application. While some studies have indicated an almost totally inelastic demand, others have shown a disastrous loss of activity when users were asked to pay as little as a fifty-cent phone call. These studies are clearly not immediately comparable, and the relevant factors involved are poorly defined. In some cases where substantial income has been derived, there has been no visible improvement in product quality, and one may well suspect an unintended distortion based on the economics of monopoly.

There is inadequate research to predict its effects.

Underlying attempts to control the array of services through pricing is the concept of "market choice", a kind of implicit faith in the ability of competition to define and serve real needs. Yet knowledge is often an ambiguous quantity, not subject to packaging and marketing in the conventional sense. Even the most

tangible information products and packages are as difficult to control and restrict as prohibition-era alcohol --witness the Williams and Wilkins case.

Knowledge is an intangible--difficult to package and market.

The nature of information is not constrained. Its value is often scattered across the entire economy, appearing only after an undetermined time to fill a hitherto undefined need. That value can depreciate under the onslaught of new information, but it grows rather than diminishes with added consumption. As long as information remains in the realm of a public good, directly related to the pursuit and externalities of research and development, it seems inherently difficult to regard this flow of knowledge as necessarily a marketable commodity. Rather in this realm, it is intrinsic to the research cycle, and one should question its adequacy in this support role rather than seeking some irrelevant market price.

A better test is support of research activity.

As we have discussed previously, however, the pursuit of research is only one aspect of the information flow. In contrast to this basic academic utility, the conversion of information to competitive technology and its diffusion into the private sector are surely subject to market considerations. Since this development and application pattern is also accompanied by a need for substantial adaptation, investment, and contest, it seems more than appropriate that responsibility for this flow belongs in the realm of the private entrepreneur. Through constant risk and exploration in a "sudden death" environment, such entrepreneurs are far more able than government or academia to weigh and test the infinite pressures, demands, and risks of the real world.

Transfer to the private sector calls for the skills of entrepreneurs.

This essential difference in marketing roles has been inadequately recognized and supported. Numerous

government research organizations, large and small, have chosen to buttress their appeals for funds with the secondary benefits of technology diffusion. "Technology transfer", "technology utilization", "research applied to national needs", and "research support for local agencies" are typical labels. Certainly technology-growth and solution-of-societal-problems are among the most trenchant and common justifications for research.

Technology transfer and spin-off are principal justifications for research.

Perhaps with some cynicism, the role has usually been assigned to the agencies' information services who have often chosen to extend their domain by engaging in large-scale attempts toward direct sale of their information and technology to the private sector. The process continues despite the fact that much of the useful technology was ancillary to the original research thrust, of minor interest to the research community, and as a result remains undocumented, much less marketable . . . simply reflecting the basic orientation toward research and development rather than the pedestrian needs of industry. This vast difference in perspective also means that efforts toward technology transfer are often undertaken with a patronizing, academic, and cavalier disregard for the grim realities of real-world economics. This substantial thrust toward direct intervention in market areas could surely be more responsively addressed by the private information industry.

However, their practice by some research agencies is often patronizing and academic.

As an unfortunate corollary these information services have not usually regarded service to the information entrepreneur as a significant role or responsibility. If one believes that institutional services are best equipped to address long-term archival needs and to provide operational services within the research and development community . . . If one believes that private

entrepreneurs are best equipped to advance the process of diffusion into the private sector, constantly exploring and testing new products and services against the hard facts of market place economics . . . If one further believes that this diffusion process is a highly desirable portion of science's externalities and indeed its most common justification, then one must surely conclude that the interface between major governmental information resources and private information entrepreneurs is an area of critical concern to which almost no attention has been addressed.

Private entrepreneurs are better equipped for the role.

The absence of concern for this interface is striking. There is a quite apparent distance, if not hostility, between these communities which should in fact be part of a single diffusion and transfer system. Despite continued publication and discussion of "technology transfer" there is almost no concern for this approach, and the prevailing institutional attitude appears to be *"Mother, I'd rather do it myself!"* This is clearly not in the public interest, especially when the interface between two eighteen billion dollar per year research and technology communities is at stake. It is time that technology transfer studies addressed this gaping chasm instead of promoting the naive assumption that institutions can replace the responsiveness of the private entrepreneur.

Research and exploration of this technology transfer interface is urgently needed.

RECOMMENDATIONS

In the foregoing discussion we have highlighted what we believe are the critical issues and open questions relating to the economics of scientific and technical information. There is hardly an area that does not call for more and better research--yet the need is not nearly so much for quantity as for a more coherent and meaningful pattern. Our overview has suggested several rather general concerns about the thrust and quality of research which might contribute to the development of such a pattern, as well as three specific topics which deserve high priority.

General Concerns

Professional Skills

We have repeatedly noted that much of the work in this field is conceptually and methodologically inadequate to its challenge. The skills required are varied and complex, and tenable results which can be transferred, cumulated, or replicated are difficult to achieve. Despite good intentions, there are numerous examples of inappropriate mixtures of strategy and methodology. Fewer studies by more experienced interdisciplinary teams able to recognize these inconsistencies would be far preferable and more likely to contribute significant information.

It has become clear in the course of this study that economic and information skills must also be complemented by a much more sophisticated level of talent and experience in operations research methodology than either economists or information workers usually command. The three must work together to develop techniques and perspective that can later be applied by less sophisticated workers and guide the methodology for future efforts.

The inherent difficulties of the research required and the obvious need for interdisciplinary approaches suggest to us that activity

should be directed toward the formation and encouragement of *Centers of Excellence* where a critical mass of appropriate interest and skill might be assembled and maintained. There are several locations where such a focus has begun to develop and shown productive results. A conscious effort to support interdisciplinary activity at these locations can both reinforce their demonstrated insight and accomplishment and also encourage assembly of the appropriate talents elsewhere.

We have noted periodic indications of a misguided faith that an economist is somehow better equipped to explore policy issues than are participants in the information field. This mysticism should be dispelled. While economics does deal with the consequences of conditions, policies, or choices, it is no better equipped than information science to suggest policy. Analytical skill is only a working tool, not a substitute for or guarantee of insight and judgment. If these skills from the essential disciplines are assembled in a critical mass, we believe the resulting insight will provide the base which is needed to formulate and debate policy.

Validity

Much of the published activity cannot withstand close scrutiny, either because of weaknesses in the research itself or because it is reported in insufficient detail or clarity. The frequency of such occurrence is disconcerting, and we suggest that future proposals for research in this difficult field should present not just a good idea, but a clear and convincing case of the participants' ability to work in the area selected. Good research ideas do not automatically generate useful research performance. While there will undoubtedly be significant projects that do not require a heavy involvement of all of these skills, it is essential that any multidisciplinary difficulties be addressed by multidisciplinary talent. Furthermore, this cannot be accomplished simply by including a token representative of any requisite skill on the project staff.

We suggest potential researchers give increased attention to four critical areas which seem to have been regularly ignored:

1. Concept. Will the project really extend the state of the art, or is it destined to produce an equivocal result, an insignificant exercise, or an unnecessary repetition of previous work (worse yet, all three)?

2. Understanding. Do the participants know what has been done before? Do they understand the complexity of the system they intend to probe and are they able to define the problem in tractable proportions which they are competent to address?

3. Implementation. Are the participants able to apply, and do they know the strengths and weaknesses of, different methodology? If they are going to collect data, have they demonstrated experience in the vicissitudes of real world data collection and will their performance be credible to the practitioners in the field as well as replicable by other researchers?

4. Reporting. Does the proposal indicate that the goals and results will be reported with a clarity and detail which will not require a translator for the average reader, yet the methodology will be decipherable by the expert?

Strategy

We especially emphasize that the complexity of the field results in an uncertainty principle of striking significance to any research program in the economics of information. Attempts at global representations, models, or generalizations must forever appear as an extremely poor and unconvincing approximation of the real world. As a result they tend to fail in the challenge we would most fervently wish they could meet. They cannot communicate effectively to the unbeliever (whom we define as one not already confident of the value of information services). On the other hand, localized, targeted studies of more limited scope can provide credible information. Accumulated over a period of time, the pattern evolving from such limited projects can provide sophisticated support for intuitive judgments. The development of elaborate mathematical models based in cavalier fashion on the assumption of unmeasurable quantities shows far less

promise than less glamorous attempts to simply collect a body of data against which future models could be tested.

Methodology

There is a pressing need to develop, document, and disseminate standard approaches to collecting comparable data on information activities. Studies should be encouraged with this specific goal in view--to define a particular class of data collection problem, develop an appropriate methodology, and demonstrate its application in specific, real-world circumstances. The approach should then be widely disseminated so that it may serve as a standard and model for such measurement in appropriately similar data gathering. (Some incentive is also needed to have the data gathered.)

Principal Concerns

The foregoing discussion describes our strong general concern for the structure of research in the field of scientific-technical information economics. Far more important in our view, however, are three principal gaps in the research effort, topics of such far-reaching importance to the scientific and technical information industry that we believe they should stand near the top of OSIS priorities. If addressed vigorously they could result in a truly substantial impact on the information community.

Key Data and Information

The state of substantive information regarding the scope, range, participants, and costs of the scientific and technical information industry is truly appalling. There are few quantitative indicators available to help answer even the most mundane questions. The significance of this gap to an economics of information research program is overwhelming. Since our comments are by no means the first emphasis on the problem, it is hard to understand the tolerance of the continuing void. Without some reasonable base of

data and information, it is difficult to claim or develop any real understanding and perspective of the field in which we work. Without some body of data and information to test their validity, our economic models are destined to remain academic exercises. Without a continuing ability to summarize the cost and activity of principal segments of the industry, it is impossible to make truly rational judgments regarding priority, utility, and accomplishment.

We suggest a systematic program on a substantial scale to begin answering these questions. We recognize the difficulty of establishing suitable measuring and reporting techniques, but this is all the more reason to begin.

To be meaningful, such reporting must cover the full range of research communication, not simply the mechanics of information processing. Figure 3 summarizes the principal areas and indicators which are needed to establish such a quantitative perspective on the activities of the scientific and technical information industry. It embraces both the full range of the research cycle and the full process of diffusion into the private sector. If filled, this matrix would provide an invaluable overview which could allow policy makers to examine our real operational priorities and allocations . . . and to weigh them against the overall activities of science and industry and our intuitive assessment of value.

As previously described, we suggest encouraging a number of projects to develop methods and practices for gathering data. Established as an example in a particular circumstance, the techniques could then be extended broadly (perhaps with gentle persuasion) to representative portions of the industry. Bit by bit a pattern of data collection could be established, providing at first a series of exemplary descriptions upon which to base intuitive extrapolation and eventually leading toward a continuing base of credible data across the industry and its activities.

The Public/Private Interface

We have described at length a major confusion of roles which we see in the elaborate diffusion process euphemistically labelled "technology transfer". Here too, we are not the first to suggest that the process is

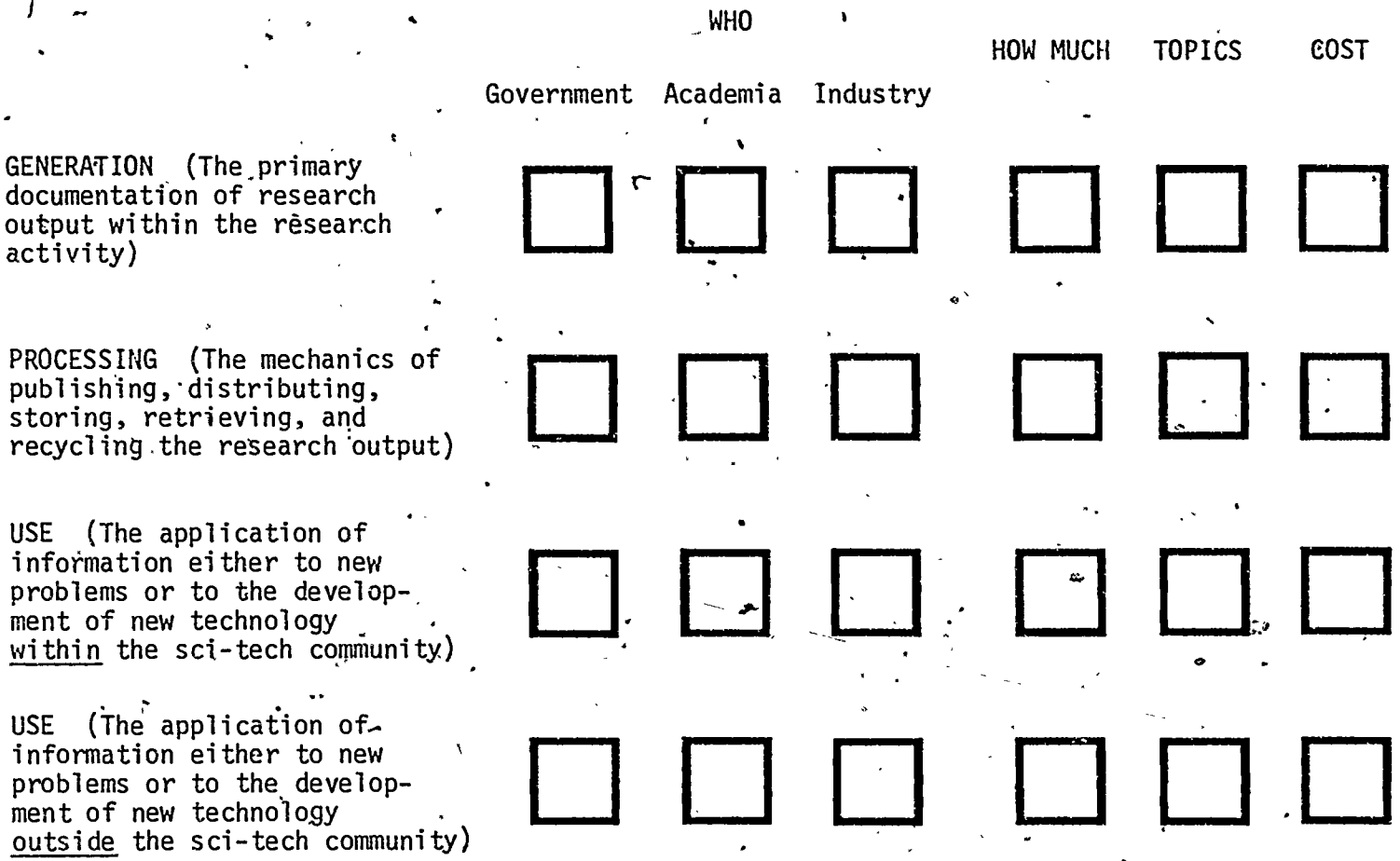

Figure 3. A Matrix of Needed Data and Indicators

far from perfect. We have also noted that some of the major activities reflect a patronizing and inadequate appreciation of the complexity of the real world. We have suggested that a major responsibility of governmental and academic information organizations should be that of a packaging and service organization providing support to private entrepreneurial organizations engaged in the repackaging and marketing of information to the private sector.

Not only have governmental agencies tended to reject or ignore this area of responsibility, but in a number of cases have funded the establishment of quasi-governmental organizations. These, in turn, actually compete with any entrepreneurs who have the temerity to enter this arena. If such an entrepreneurial community developed on a substantial scale its existence and size alone would serve to indicate the value of technological spin-off. In our view, study and demonstration programs in this area should occupy a priority, second only to the need for industry data.

Economics/Information Understanding

At present few in the information field are equipped to understand and converse intelligently in either the economics area or in operations research. Successful research on the economics of technical information must depend upon cooperative efforts among economists, information specialists, and operations analysts. What may be less obvious is that such activity does not appear as a simple consequence of association but rather depends upon interdisciplinary education and dialogue. Although we would assign it somewhat lesser priority than the foregoing, a program to provide continuing professional education couched in the language and perspective of information science together with a series of interdisciplinary "confrontation" exercises could provide a valuable basic underpinning to future activity.

* * *

Lest these recommendations appear unduly philosophical, we cannot overemphasize the need to relate economics research to a practical framework of questions. We have indicated the general character of such questions as well as suggesting a conceptual data framework in Figure 3. Together they could provide critical support in the formulation and consideration of scientific information policy. We have also stressed a major gap in the information transfer process. If these suggestions alone are convincing, our efforts will have been well spent.

APPENDIX

SELECTED LITERATURE ON THE ECONOMICS OF THE SCIENTIFIC AND TECHNICAL INFORMATION INDUSTRY

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SELECTED LITERATURE ON THE ECONOMICS OF THE SCIENTIFIC AND TECHNICAL INFORMATION INDUSTRY

Introduction

The material reported in this section constitutes an organized summary of the primary literature support for our conclusions and recommendations.

We began our project in April 1974 with the traditional literature search of material in the ERIC Clearinghouse on Information Resources, a search for on-going research in the Science Information Exchange and the Defense Documentation Center, the bibliographies of the 1972 and 1973 Annual Review of Information Science and Technology (ARIST) chapters[11,65]*, and Olsen's Economics of Information bibliography[39]. The apparent volume of pertinent published material was overwhelming.

While it was sometimes possible to look briefly at some of the documents cited and determine that they were not significant to this study, far more frequently a detailed reading and rereading was necessary simply to decipher the message. And, although we might admit to a modicum of prejudice, we would have to declare a tossup between information experts and economists on levels of obfuscation.

Technical reviewers with economics and operations research backgrounds tended to reject almost everything as dubious methodology. Librarians and information scientists were appalled at the simplified modeling of complex processes. Nobody cared much for the quality of the "givens" in many of the studies. Short of being able to sit across the table from each of the authors to obtain further clarification, there proved to be no way for all of us to agree on whether some of the approaches

*References are listed on page 55.

might have more significance in another context. Accordingly, this review is not a critique of each item we examined; rather it pulls together items from the relatively recent literature and a few significant older studies to typify the activity in the field.

Although we reviewed some hundreds of books and publications, it is not practical to provide here an indication of all of the material we examined. Much of it proved to be of the "this works for us" variety, based on simple, well known methodology. Even more of it was commentary, speculation, exhortations, and other such nonresearch. Our coverage ranged widely into the literature of the social sciences, accounting, and marketing. We found much material of a qualitative nature that could be useful background for NSF's OSIS programs, but was not directly significant to the needs of this project. Consequently, as a separate part of this effort we have provided OSIS with our working file of extracts and annotations of all material reviewed. This file is not available for dissemination.

* * *

Our subject matter was neither easy to locate nor easy to categorize once located and read. We have developed great empathy for the bibliographers who characterized the literature on evaluation of information systems as *"piecemeal, noncumulative, and in a rather fundamental sense, moribund"*(30). While moribund would not be our adjective of choice for the literature on the economics and marketing of scientific and technical information (enigmatic perhaps and, often, unintelligible), we found few research thrusts that could be considered additive, or even complementary, except in a very few areas.

Although some of the reported research related directly to the economics of scientific or technical information services or libraries, many of the activities have considered broader-scope collections, particularly academic libraries and even a few public libraries. Objectives of the individual studies vary, and often they are not really identified.

In retrospect (and unfortunately still too frequently in prospect) the library situation is viewed by many as fuddy-duddy land where the librarian/information specialists sit in one camp. The computer man, the systems analyst, the operations researcher, the cost analyst, the scientific manager, and, certainly, the economist, all occupy positions in other camps at some distance from the libraries. Between camps communication is difficult, if not impossible. The librarian is seen to need shaping up to join the modern, technology-oriented, management world . . . all that is required is to learn how to use some of the vast array of "exotic" tools that are available. While there is probably some truth to this picture, it is unfortunate that it seems to have led to considerable misapplication of resources where cooperative efforts might have been more meaningful.

Many of the studies were motivated by honest attempts from all camps to develop bases for managing library/information activities more "effectively". Of course the definition of this is fuzzy. At the risk of gross oversimplification, we might characterize the studies as investigating .

- Value
- Quality
- Demand
- Markets and Market Failure
- Cost
- Cost Effectiveness and Cost Benefit.

In practice, the distinctions are blurred and both intentions and results are often difficult to interpret.

Cost Benefit Analysis (CBA)

There is considerable evidence that CBA is just jargon to be bandied about when budget overlords or funding agencies make "accountability" noises. Many authors seem unconcerned with such rudimentary considerations as

- *What is it?*
- *Why do it?*

Consequently, lack of a firm grip on *How to do it?* in the information field probably should not be criticized too severely.

The essential elements to be remembered are that CBA is only a tool to help decision making--to help make more "economically rational" decisions . . . which generally means more justifiable to somebody. CBA is a tool, not an "answer". CBA purists insist that the process involves comparing "all" costs and "all" benefits in terms of a common unit, generally money; thus distinguishing it from cost effectiveness analysis, which does not attempt to put a dollar value on benefits.(18) In actual practice, says Williams(64), the distinction between the two "will only be a matter of *degree* (and, on occasion, perhaps only a matter of *intent*)".

How can we value information/library services? Information services have difficulty enumerating benefits, considerable difficulty in measuring them, and substantially more difficulty expressing them in dollar terms. The literature is filled with words on the subject, all seeking or suggesting answers to the basic question: *How much good does the service do?* Few answers or approaches can evoke any response other than *Sez who?* because they have meaning only in terms of the specific context in which they were developed. Unfortunately, seldom is this context sufficiently well defined to enable useful comparisons.

A companion question, *How good is the service?* introduces the idea of quality, which is a factor in the service's performance (i.e., its effectiveness in satisfying its objectives). Obviously, value and quality are related. Orr(42) shows them as a cause and effect sequence looped on itself (Figure 1). Consequently, measures of resource

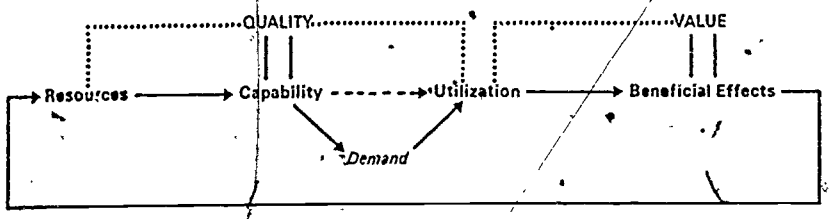

FIG. 1. *Relations among criterion variables*

[Reproduced with permission from reference 42.]

allocations may be indirect measures of value as well as of quality, and utilization measures usually reflect both quality and value and may be considered indicative of benefits.

"Goodness" also may be evaluated in terms of the proportion of needs that are being met--a "satisfaction" ratio. Or it may be evaluated in terms of accessibility and of response time. The essence of the quality (effectiveness) measurement problem is twofold--define the needs that a service is intended to meet, then determine which of the needs it is capable of meeting. The complex relationship between needs, demand, and utilization is shown in Orr's Figure 2.(42)

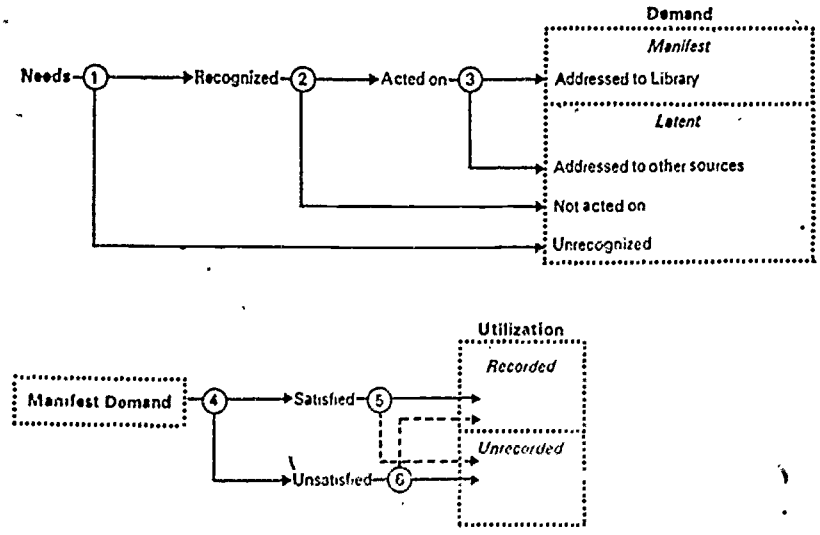

FIG. 2. *The nature of demand and its relation to utilization*

[Reproduced with permission from reference 42.]

Cost Effectiveness Analysis (CEA)

Effectiveness is some measure of performance or goodness or value, some multidimensional pay-off in arbitrary units. Cost effectiveness analysis attempts to relate the measures of effectiveness to the cost of whatever is being measured. Cost effectiveness analysis may be helpful in deciding on

- Whether one project is preferable to another
- Allocations of a given budget
- Procedures for performance review and control.

Thus it is not as powerful a tool as CBA, which may be helpful in deciding whether or not a project is worthwhile as well as the amount to budget for activities or to charge for services.

Flowerdew and Whitehead of the London School of Economics recently completed a significant review of "Cost-Effectiveness and Cost/Benefit Analysis in Information Science".[18] Their recommended directions for further research closely parallel our own in some respects, but we believe more direct discourse and debate between the concerned economics and information experts could achieve useful modifications in both.

Multiple measures are almost always necessary to express the effectiveness of an information activity or system. Cost effectiveness analysis supposedly requires that these must somehow be combined into a single index of effectiveness. Lancaster[31], in what has been called the single most influential information science article on cost effectiveness analysis[30], clearly outlines the basic steps involved. His approach, however, is to look at individual measures separately, analyzing effect of change on system cost and efficiency. Thus, with search yield per journal as a measure of the effectiveness of coverage of an information retrieval system, journals can be ranked by relative contribution to retrievals. If 30% of the journals contribute 90% of the total search usage, input costs may be reduced by decreasing journal subscriptions, with little loss in effectiveness (at least by this measure!). He mentions many other possible indicators of effectiveness of coverage, each of which might be examined and trade-off decisions made. Presumably the information

system manager makes the decision as to which effectiveness measure is the most valuable or significant to the CEA. The economist (and probably the funders) would prefer that more effort be put into combining these measures via a weighting scheme which is stated rather than implicit.

Value and/or Effectiveness

There are three basic approaches to quantifying values attributed to information services:

(1) Seek values directly from people

(2) Impute values from people's actions

(3) A combination of these.

Asking the user to assign values is one approach, asking the librarian, is another.

A few studies attempt to avoid most of the direct measurement problems by considering that since the librarian's resource allocation decisions are based on perceived needs, these actions should be indicative of the value of services. At the University of Durham, Hawgood et al.[16] built a linear programming model for the allocation of resources in university libraries which is based on working backward from the policies adopted by the library managers to determine the criteria that must have been implicit in shaping these policies, providing an imputed value of marginal benefit for each activity.

Wessel et al.[62] also use librarian's judgment of value in one of the techniques they developed for evaluating Army libraries. The SCOUT technique (Service COmponents UTility analysis) is based on the librarian's subjective judgment regarding the utility of services and operations in meeting the mission of the library. The value of the typical need met in each different service is ranked in order of importance. An arbitrary index number is assigned to the middle ranking service and the others are given weighted ratings in relation to this index. These arbitrary unit ratings are called "utils". The average number of needs met is multiplied by the "utils" to derive a base utility measure for each service.

While Wolfe et al.[66] consider that Wessel's procedure lacks credibility because different librarians gave different utility measures to the same services, they too obtained information officers judgments of value. Their purpose, however, was to compare them with values assigned by users to determine whether they could be proxies for the user evaluations. Their results do not indicate any relationship between the values,

although they admit some possible methodological difficulties which would require further study before definitive conclusions could be drawn.

Olson's[40] weighting scheme for the value of different aspects of library service is based on a consensus judgment of groups of Indiana librarians. They divided 1000 points among service activities specified in a detailed service policy outline to indicate those service policies important in an "ideal" library.

The Institution of Electrical Engineers[23] attempted to assess the relative value of INSPEC services (current awareness publications, SDI, and abstracting services) to the subscriber's organization by asking a sample of subscribers to distribute approximately 100 points among the services to which they subscribe. The majority of such subscribers however are librarians and information officers rather than the direct users. The results clearly indicate an essential problem with the use of such arbitrary scale units that can have no comparable meaning to different users. At least one of the respondents apparently gave a zero value to a number of the services, which presumably they are buying!

Wolfe et al.[61] asked users to distribute 100 points between four competing information services: published secondary information, trade literature, personal contact within and personal contact outside the establishment. They were also asked to give a 1 to 10 scale rating to the importance of different characteristics of an information service, a 0 to 100 rating of satisfaction with the services they use most, and other similar ratings. These authors also asked users to hypothesize

- The increase in salary that they would require to compensate for the withdrawal of secondary information.
- How they would adjust their hours allocated to R & D and to information work to compensate for withdrawal of secondary information.
- If they adjusted their hours to decrease research time, how many extra hours of R & D work would be required to maintain their previous research output.

Lancaster[32] reports a semantic-differential type value judgment by users of on-line searching in MEDLARS, along with a user's time cost per relevant citation retrieved.

Others have considered users time as a value measure. The contribution of a service to achieving organizational objectives can be measured by the user's time savings effected.[8,13,17,42] Another user-time measure is the personal time allocated to the service by the user.[35,42]

Still other ways of looking at value or effectiveness incorporate trade-off considerations between the performance level of the system and the combination of user and system time that is spent working with the system. Cooper[10,12] suggests a model for such an evaluation.

Weinberg[61] proposes a Bayesian approach to value of library resources wherein users initial estimates of value of items are revised after each item use.

Andrus[1] suggests that the concepts of form utility (format, jargon, symbolic system, volume), time utility (availability when needed), place utility (physical accessibility), and precision utility (organizational location) should be useful for understanding information value. He acknowledges that it is easier to identify utilities by their absence than to measure their presence and suggests a pragmatic approach of checking for their absence, then redesigning the system to provide them or discount the information for their absence.

Rzasa and Baker[54] propose effectiveness measures based on the proportion of needs (manifest demand) that are being met by the university library. They define three specific measures of effectiveness based on number of users, total user population, material reshelved, reference questions asked and answered, and space users. They propose combining these into a single measure by weighting each in terms of what the university library administrator considers desirable equivalencies. We hope their example of desirable equivalencies, such as an increase of 20 space users (people in the library who are not using library materials) or of 3 more items reshelved are each equivalent to an increase of 1 reference question answered, have some underlying rationale which might make them more palatable.

Pritchard et al.[50] of City of London Polytechnic apply these measures to compute effectiveness data from information obtained by user

questionnaire and a reshelving survey. They do not, however, use the weighting scheme but simply sum the three measures. The intent apparently is to compare the measures with future data obtained after changes in the service.

In addition to techniques for measuring satisfaction ratio by direct determination from users, several approaches have been used which make the determination by *simulating* users.[42] Orr[43] has developed a standard "Document Delivery Test" for biomedical libraries which measures the library's capability for meeting the manifest demand of its users. The general method is applicable to other types of libraries if appropriate test samples can be established. The method has been used by Orr[44] to assess the capability of 92 medical school libraries for meeting the needs of biomedical researchers and of 15 major resource libraries for filling biomedical libraries' interlibrary loan requests. A mathematical model relates the capability actually afforded to its users (virtual capability) to its basic capability. Regression equations provide a technique for predicting basic capability from collection size.

Hamburg et al.[24] suggest three methods of measuring document exposure--a combination of proportion of user demands satisfied and response time--called exposure counts, item use days, and exposure time.

Project Intrex[45] reports on an interesting approach to modeling an on-line interactive computerized information retrieval system for economic analysis. Costs and user service requirements are inputs to the model; net profit and service index are the outputs, serving as "figures of merit" for the system. The level of service and profit can be adjusted up or down depending on local policy decisions.

Demand

Young[67] reports a preliminary economic foray into analysis of the demand for book loans from the public library, attempting to establish the interrelationship between the factors influencing the demand. He used published data of 1952-53 and 1961-62 from a cross section of libraries in England and Wales. To develop his model he likens the public library lending service to a retail store. The consumer's decision on whether or not to shop is based on the probability that the trip will be a success and on the cost of getting there. Probability of success is influenced by level of service available, cost by time or distance involved in travel. Other significant factors are the consumer's degree of literacy and his level of income. A two equation model is postulated, which is assumed to be linear. Although the results are interesting, they suggest the need for either a better model or more appropriate data or both. The author suggests that rather than expend time and effort for obtaining more adequate data, a systems simulation approach to developing a model might be more fruitful.

Barzel[2] studied the market demand for a specific information commodity (the *American Economic Review*), which he characterizes as a "semipublic good". Berg[4,5] has concentrated on modeling the scientific journal market and evaluating the effect of different price and page policies on demand.

Baumol[3] suggested an abstract commodity approach to estimating the demand function for professional journals, treating the journal not as a physical entity but as a bundle of attributes (attributes significant to the user).

The common special library problem of "acquire or borrow" for periodicals is addressed by Houghton and Prosser.[27] They tested Brookes model, which is based on average journal costs divided by average costs of a photocopy, against various sets of usage data from special libraries. They rejected his model and developed one which is based on actual journal costs plus processing costs. This cost of each journal is divided by the actual use (usage data consisting of photocopies, loans, and in-house current awareness) and this cost-per-use value for each journal plotted in

ranked order of use. This modification clearly produces a more realistic picture of journals that can profitably be retained. Their extension of this approach to a cumulative costs vs cumulative use generalized model is not quite so clear. Further work should be interesting.

Bookstein[6] combines queuing theory and dynamic programming to consider the problem of allocating resources--whether people or equipment or money--among various locations in an information system where phases of a process are carried out. Use of the technique to calculate the in-house distribution of computer terminals among various functions requiring access to a computer (given a fixed budget) seems reasonable, if all user waiting time has the same value. However, the extension to deciding upon the distribution of workers among the various phases of the process of cataloging a book (based on the funds available for the process) seems unrealistic.

Newhouse and Alexander[38] set about developing a tool that would help public libraries decide which books to buy, that is, how to allocate their book budgets. The idea here is, given a stated book budget, how should the librarian make the choice between types of books to be purchased so as to derive maximum benefit from the funds. The choice assistance is applied to buying more or less books in reasonably homogeneous classes, such as more on Psychology and fewer on Linguistics, not to *which* books to buy. Their approach is to compare the demand for individual purchase and the demand for borrowing, assuming that if the library had not purchased the book, borrowers would pay, at most, the price of the book to borrow it. They measured intensity of preference by asking users to indicate whether or not they would have bought the books they used in the library. They used circulation data for a year to establish demand for each class of books. The method is interesting (Flowerdew and Whitehead[18] provide a critique), and it is conceivable that it might be applied to a sci-tech collection.

"Demand" for sci-tech information services or products within the information industry is usually identified by some form of "user needs" study--frequently very informal. We found few indications of formalized market research analysis (other than in-house and unpublished) prior to

introduction of new sci-tech information systems, services, or their modifications. Commercial publishers frequently conduct such studies, but their results or methodology are seldom publicized. In the government arena, NTIS is known to have done a number of such studies--a few of which have been published.[29,59] Basically, these are the "what will happen if?" type, designed to help make format or content or pricing decisions on a specific product.

Hyslop[28] discusses the effect of the 1966 ASM market study, the impact of which is still seen in the views on information support of professional society membership and industrial management. Engineering Index commissioned a market study before introduction of its energy spin-off publication.

"Marketing" of services is a way of life for the profit-making segment of the industry, and a subject for discussion, debate, and frequent misapplication in much of the rest of the field. Veazie[60] discusses the marketing issues for information analysis centers.

Markets and Market Failure

In this area of research the distinctions between scientific and technical information and "any" information are sometimes considered very significant and at other times ignored. While our aim was to explore the research on economics of scientific and technical information, we found that much of the recent interest--particularly by economists--has been in the all-inclusive concept of information, and we did review some of this material.

A competitive market system exists for some information products, yet market failure also exists. Furthermore, information problems also *cause* market failure in other markets. Spence's recent chapter in the Annual Review of Information Science and Technology, "An Economist's View of Information"[57] concentrates on the research into market failures and the relationship of information to these failures.

A substantial portion of the literature on the *value of information* has been addressed to information in the market context--that is, as needed for individual choice. For example, Andrus[1] focuses on two approaches, Bayesian analysis and utility analysis, to determining the value of information for management decision making, primarily from the view of the marketing manager who must determine whether or not to acquire information. Earlier work with simulated marketing environments by Green et al.[22] explored the use of the Bayesian model for describing information acquisition and use under experimental gaming conditions. And, of course, there is the pioneering work in team theory by Marschak and Radner.[37]

Dermer[14] looked at the relationship of an individual's tolerance of ambiguity and his perception of what information is important in an administrative information system. Hirshleifer's 1973 paper on the theory of information[26] specifically considers the market context, reviewing the behavior modes for possessors and seekers of information and the attributes affecting the value of information to the potential users or producers for the cases of technological uncertainty and of market uncertainty.

Marschak[36] questions whether the technology of producing symbol-processing instruments and services favors the existence of competitive markets. Olson[41] discusses public goods and externalities as the main source of market failure and how the information producing and disseminating industry fits the collective good condition--sharply decreasing costs--with implications for government subsidies, particularly for libraries.

Cost

We did not attempt to look for all cost studies per se, but many of those that had a research orientation, were part of a more comprehensive study, or were cited in recent literature have been examined. The primary issues discussed are cost accounting, cost analysis, and ways to establish unit times and costs. Most of these were published in articles on cost-benefit analysis but are described here only in terms of providing dollar cost estimates.

The methodology for determining costs exists; what is generally lacking is simple, consistent definitions of what to measure. Studies cost money, and administrators must be strongly motivated to divert adequate funds to provide good ones.

Early papers purporting to provide cost accounting methods for sci-tech information services such as SIE[20], URBANDOC[55], and NASA's ARAC[25], are substantially superseded by the more comprehensive work of Douglas Price of ERIC on "building block costing".[48,49] Whether this technique, which is based on collecting costs as they are incurred in actual production and relating them to the actual units produced by their expenditure, would also be applicable to libraries is speculative but would seem to be worth investigating.

Leimkuhler and Cooper[33] provide a standard cost accounting plan for library costs which incorporates the concept of the library as composed of two major kinds of cost centers: processing centers and service centers. Service centers can include branches or specialized facilities within the library. Applicability of the plan is demonstrated with data from the Libraries of the University of California at Berkeley.

Since library services are labor intensive, the bulk of the effort on cost measurement concentrates on determining the amount of labor required to perform the various activities. Although other techniques have been used successfully in libraries to measure work activities, e.g., by Poage at Texas A & M[47], the 1970 review of cost studies by Dougherty and Leonard[15] indicates that most of the better cost studies published in the sixties

were based on the usually imprecise "diary" record. Such a major cost study of acquisitions, cataloging, and processing activities of a group of libraries is reported in the feasibility study for the Colorado Academic Libraries Book Processing Center.[34] They used a 2-week diary record. The reliance on this technique continues, particularly in Britain.

Costs of circulation at University of Essex[53] are calculated from 2-week diary records of workers and estimates of the user's time required to fill out a request and wait for its processing. Cost data for interlibrary loan and reference activities of the four general Research and Reference Centers in Illinois was developed from daily log sheets completed over a 2-week period.[46] City of London Polytechnic[9] used a diary survey over a 4-week period to establish time and cost data for more than 100 specific library tasks. Smith and Schofield[56] of University Library, Cambridge, estimated unit times and costs for acquisitions, cataloging, binding, lending and enquiries, and interlibrary loans for two university libraries, based on 12-week diary records. These authors and others, e.g. Ford[19], urge adoption of standard task definitions, output units, and the like so that libraries could collect comparable data.

Aslib has been working on library task analysis and standardized definitions for some time. In 1970 they began work on a project to develop and test methods for collecting and analyzing data on the time taken to perform the operations involved in production of a current awareness bulletin (nonmechanized).[21,52,63] The apparent intent was to develop a method that could be used to collect data in many libraries and provide comparative cost analyses.

We believe this idea is commendable. Comparable data are lacking, both within the library for evaluating potential change, and on other libraries for edification and possible cooperation. While we recognize the need to develop a method that can be simply administered in any library, we consider the research approach flawed. The considerations are complex, and we believe more sophisticated techniques of data collection and analysis should have been employed to establish the base. The applicability of the simpler methods could then be determined with confidence.

Specifically, use of the diary technique for the baseline data is not an optimum choice, particularly with two timing methods (one for library staff with watches, one for those without). More significant, however, is the lack of use of empirical classification [e.g., the Automatic Interaction Detector (AID) program] to help clarify the cause-effect relationships before the standard statistical analysis.

Combinations of self-recording and work sampling have been used for cataloging activities by Wessel[62] and for interlibrary loans and photocopying by Spencer.[58] Spencer's study involved random time selection by electronic alarm devices, and the workers recorded what they were doing when the alarm sounded.

Of course, a basic issue is, *what gets included in costs?* Operations managers concerned with budgets and funding usually want *accounting* costs. Planners want *economic* costs. While costs in time units may need qualification in terms of relative skill of personnel involved or the type of equipment used, they do seem to provide a more meaningful base for comparisons in labor intensive activities.

The problem of cost allocation to various activities is a central one. For the M.I.T. libraries, Raffel and Shisko[51] translate the library budget into a program budget (relating outputs to inputs), giving a base cost for various activities. Their program budget format is now frequently used as a pattern for other libraries. However, the allocation of overheads and capital cost depreciation used by these authors is questionable.

Bourne[7] models a library circulation system in terms of components and associated costs, and suggests a cost reporting form for library use which will permit more consistent analyses. The cost model is not based on accounting costs. It specifically excludes employee benefits and other indirect labor costs, overhead costs, facilities costs, and other allocated costs. The major unit of measure is unit costs per checkout transaction. No details are given on how the labor times reported are measured.

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